Science Connection

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EVERY CHILD PROFICIENT & PREPARED FOR SUCCESS

In This Issue

Filtering through the Engineering Practices

Sherri Brown
Associate Professor of Science Education
Assistant Chair, Early Childhood and Elementary Education, University of Louisville

ELEMENTARY

Dimension 1 of the *Next Generation Science Standards (NGSS)* includes Engineering Practices (EP), which are practices that engineers use as they design and build systems. NGSS supports engineering design in the earliest grades (K-2) where students are "introduced to problems as situations that people want to change. They use tools and materials to solve simple problems, use different representations to convey solutions and compare different solutions to a problem, and determine which is best" (NGSS Lead States, 2013, Appendix I, p. 105). It is imperative that EP be introduced in early grades so that students have opportunities to develop creative, critical thinking processes to solve problems. Teachers can use EP in teaching the concept of water filtration to addresses disciplinary core idea *NGSS 2-PS1.A or 5-PS1.A Structure and Properties of Matter*. Note that the following suggested activities can be adjusted to address higher or lower grade level instruction.

Second Grade: 2-PS1-1.A.: "Different properties are suited for different purposes."

1. Based on their previous experience, 2nd grade students predict how various items will filter/remove soil particles from water. These items may include sand, cotton ball, sponge, coffee filter, small pebbles, medium rocks, newspaper, net, paper towel, shelf paper, and gauze.
2. In preparation for testing, teachers preconstruct two pitchers of dirty water (1 teaspoon or 5 grams commercial topsoil per 1 liter of water), prepare tinted plastic cups (use small nail to puncture four holes in bottom of clear plastic cup), collect and organize test materials, provide basins for waste water, and supply paper towels for cleaning.
3. Teachers provide each student with a self-made *Predict and Test* activity sheet and a piece of white laminated paper. Prior to testing, teachers model how student groups should test each item without actually pouring the dirty water into the cup. Teachers demonstrate how to place the plain white paper behind the clear cup and how to record observations via text and technical drawings.
4. In two-member teams, students place one of the items listed in Step 1 in the tinted clear cup with holes. Students hold the

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Editor's note:

If your class has been gathering data and recording daily weather observations I would say that you have had a great deal to talk about in January! "Consistently inconsistent" might just be a summary in and of itself with regard to January's wintery weather. Although there have been several days of inconsistent weather patterns, I am reminded of the wealth of content knowledge and expertise that is consistent across the Commonwealth. This month's newsletter highlights some passionate teachers who dared to share their thinking and experience in order to move science education in to the classroom spotlight. Let's show our appreciation to them by continuing in their footsteps. Let's keep the pattern growing. I look forward to reading your contributions.

Christine

NEXT GENERATION SCIENCE STANDARDS

Practice	DCI	Crosscutting Concept
Planning and Carrying Out Investigations	PS1: Matter and its Interactions	Scale, Proportion and Quantity

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tinted cup over the clear cup while the teacher pours the soiled water into the tinted cup. This step is repeated for various items listed in Step 1.

5. Based upon data collected on *Predict and Test* activity sheet, students report what items are best suited for filtering soil particles from water.

Fifth Grade: 5-PS1-1.A.: "Matter of any type can be subdivided into particles that are too small to see, but even then the matter still exists and can be detected by other means."

1. Based on their previous experience, students select three items to construct a model filter which will filter/remove soil particles from water. Items may include sand, cotton ball, sponge, coffee filter, small pebbles, medium rocks, newspaper, net, paper towel, shelf paper, and gauze. Students draw their filter model (i.e., which layer is on top, middle and bottom) in their science notebook.
2. In preparation for testing, teachers pre-construct two pitchers of dirty water (1 teaspoon or 5 grams commercial topsoil per 1 liter of water), cut and collect top funneled portion of 2-liter empty plastic bottles (one per student), collect and organize test materials, provide basins for waste water, and supply paper towels for cleaning. The funneled portion of the 2-liter bottle should be covered on the outside grooved cap area with gauze held by a rubber band. The gauze adds a fourth layer of material or item to each filter.
3. Students construct their model filters based upon their diagrams. As each student holds the filter, the teacher pours 150 milliliters of dirty water into the top of the filter. The filters can vertically rest within plastic cup to continue filtering. After students observe and draw the filtered water in the clear cup, they describe the effectiveness of their filter (e.g., Did it filter the soil well? If not, why? Would you change your filter design? Are there any particles remaining? How do you know?)
4. Allow filtered liquid to remain in room for two weeks (this time may vary due to evaporation rates). Observe sediment that appears in clear cup. Ask students to predict where this material/sediment originated (e.g., filter items/material, potting soil). What process (i.e., evaporation of water) occurred that allowed the appearance of the remaining sediment?

With every science lesson, teachers should provide authentic connections by relating the activity to real world science. NGSS Influence of Engineering, Technology, and Science on Society and the Natural World specifically states that "every human-made product is designed by applying some knowledge of the natural world and is built using materials derived from the natural world" (NRC 2012, p. 213). Students may be surprised to discover that underground water supplies are naturally filtered by Earth materials (e.g. sand, coal, rocks) over a long period of time (e.g. tens, hundreds, thousands of years). A connection can be made to how current water treatment facilities operate. Most water treatment facilities use similar filtration methods with coal, sand and/or rocks in the water purification process. A free K-8 PBS online video, Teachers' Domain Water Treatment Plant http://www.teachersdomain.org/resource/ess05.sci.ess.watcyc.h2otreatment/, explains a typical water treatment facility process.

Note some of video's vocabulary may need clarification, such as reservoir, impurities, particles, chemicals, and residential. At this point teachers can reference their own local city, town, or community water company. Teachers can connect students' filter exploration to what engineers do at local water treatment plants.

For more activities related to water filtration, water quality, and/or water conservation, please refer to the following teacher resource: http://www.tappersfunzone.com/teacher_zone/tap_into_fitness.html

Scale, proportion and quantity…Oh my!

ALL

Terry Rhodes
CKEC Regional Science Instructional Specialist

As we begin this venture into the somewhat overwhelming world of NGSS, it's not hard to sometimes feel like Dorothy as she wanders along the yellow brick road in search of the Emerald City (or in our case, the magic formula for changing our mindset when it comes to science instruction.) We've always done a good job (we thought) of covering the content in our current standards. But a lot of the time, and I'm including myself in this, we settle for getting the content in, with an occasional hands-on activity to keep the kids interested, because there just aren't enough hours in the week to deeply engage ourselves in our own content and teaching strategies. The beauty of these new standards is that SO much of that work has been done for us; the connections are already made for us to give our students hands-on and also minds-on science instruction. These standards are the ruby slippers, if you will!

As a science educator, I am especially excited about Dimension 2 of NGSS, the Crosscutting Concepts (XCC). These are the understandings that connect the disciplines and allow our students to view the scientific world in a more coherent and organized manner. Scale, Proportion and Quantity is one of those XCC's and I am hoping I can clarify how this looks in relation to the PS1 Disciplinary Core Idea.

According to *A Framework for K-12 Science Education* (NRC, 2012) it is "critical to recognize what is relevant at different measures of size, time and energy and to recognize how changes in scale, proportion and quantity affect a system's structure or performance." So what exactly does this mean? In a nutshell, it means that we're talking about the

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sizes of things and the mathematical relationships between them. Let's break it down a little bit more:

Scale is usually described in terms of range and magnitude, but we have to remember that the word scale has multiple meanings. We have to be sure our students understand that in science, when we talk about scale, we are referring to the properties of an object that can change as size is increased or decreased and the behavior that changes as a result. According to *The Framework*, there are "three major scales from which we study science: 1) that which we can directly observe, 2) those that are too small or fast to observe directly and 3) those that are too large or too slow." In order for our students to understand that which they cannot directly observe, the concepts of ratio and proportion become critical in allowing them to make both mental and physical models. Understanding scale also requires insight into measurement and quantities, as the ability to recognize relationships among different quantities is crucial in interpreting observations and inferences.

So what does this XCC look like as we progress through the grade bands? According to the NGSS progression, at K-2 we want to include:

- Measurement
- Counting, comparing quantities, ordering quantities
- Use of scale models, diagrams and maps

At the 3-5 level:

- Measurement with standard units
- Understanding that with natural objects, scales range from very small to immensely large
- Constructing and interpreting data models and graphs

At the MS level:

- Estimating
- Powers of 10 scales
- Using algebraic thinking and equations
- Recognizing the function of a system may change with scale and that phenomena observable at one scale may not be observable at another scale

And at HS:

- Being able to move back and forth between models at various scales
- Understanding that the significance of a phenomenon is dependent upon the scale at which it occurs
- Using more complex algebraic thinking and statistical relationships

OK, all well and good, but what does that look like in physical science in your classroom?

Beginning with K-2, it's using relative scale to allow objects to be compared and described, such as bigger and smaller, hotter and colder, faster and slower. For 3-5, allowing students to discover that standard units are used to measure and describe physical quantities such as weight, time, temperature and volume.

In middle school, students should understand that proportional relationships (e.g. speed as the ratio of distance traveled to time taken) among different types of quantities provide information about the magnitude of properties and processes. Scientific relationships can be represented through the use of algebraic expressions and equations.

In high school, students should be able to understand that relationships between different types of quantities can be represented by proportions and ratios, such as velocity is a ratio of distance traveled versus time. They should also realize that the structure of matter at the atomic and sub-atomic scales helps to explain a system's larger scale structures, properties and functions.

Finally, I'll leave you with a short, and in no way comprehensive, list of science teaching examples as pertaining to physical science and Scale, Proportion and Quantity (See table below).

Hopefully, I've been able to bring some clarification as to how the XCC'swill add another whole dimension to your instruction and student understanding. And for the record, you're not alone on this adventure along the Yellow Brick Road! All across the state, we are working together to begin this process of deeper thinking and intentional instruction that will bring our students what the Great Wizard cannot give them –an appreciation for the science and scientific understanding that has already occurred and that which lies in their future.

References:

A Framework for K-12 Science Education. The National Academies, 2012

www.learningcenter.nsta.org : NGSS Crosscutting Concept

Measurement	Scale	Proportion	Quantity
Tools for measuring physical properties (e.g., meter stick, graduated cylinder, balance, electronic scale	Types of scales, such as the pH scale	Proportional relationships such as speed, density and pressure	Counting quantities
Using relative tools for measurement, such as clapping or the length of the hand	Relative scales	Concentrations and dilutions in chemistry	Comparisons of counting
	Scaled models and diagrams	Ratios of molecules in chemical compounds	Ordering of quantities
		Algebraic equations	Creating, analyzing and interpreting graphs

Helping students classify matter

HS

Wanda Battaglia
Boone County High School, Chemistry Teacher

Traditionally, students might look up the definitions of element, compound, homogeneous mixture, and heterogeneous mixture in their textbooks, and then be asked to develop a "matter" flowchart showing the relationship between these terms. Afterward, they might be given a worksheet where they practice identifying everyday examples as elements, compounds, or a type of mixture. And then, the teacher moves on.

My experience over the years is that students don't fully grasp scientific vocabulary and they need more concrete examples. In chemistry, students need to have the ability to visualize interactions between various types of particles such as atoms or molecules in order to adequately explain various physical and chemical properties and processes.

The Classification of Matter lesson below (condensed version) consists of two activities used within the first few days of school that initiate the visualization of the nanoscopic world of atoms and molecules, and allows multiple modes of internalization of the meanings of "element, compound, or mixture". At the end of the two activities, students are better able to identify elements, compounds, and mixtures according to definition, everyday examples, a 2-D picture representation, or a 3-D model representation of them.

Important Note: The activities can be used in reverse order, depending on how a teacher would want to approach classifying matter.

At the beginning of the lesson, students are asked the following question:

Check-In (Engage):

In the Penny for Your Thoughts activity, you used the following substances: zinc filings, sodium hydroxide solution and water. You also produced brass, which is a metal alloy, at the end of the activity. Based on your current knowledge, classify each of those substances as an element, compound, heterogeneous mixture, or homogeneous mixture.

During a class discussion, the students develop an initial idea of the differences in those substances and how they are classified to kick-start their thinking for the two activities.

Explore:

Students will do both activities with a partner.

The first Classification of Matter Activity was designed by me. Below are the stations used, although a teacher could use whatever examples they would want. Each station contained a label with the following information, an actual example of it, and some kind of model to represent it (molecular model, Lego model, etc.).

Classification of Matter #1 Stations:

Station 1	Ethanol and Water Solution
Station 2	Methane (CH_4)
Station 3	Distilled Water (H_20)
Station 4	Copper (Cu)
Station 5	Water and Oxygen
Station 6	Salt (NaC1)
Station 7	Brass
Station 8	Pepper, Sand and Water
Station 9	Oxygen (O_2)
Station 10	Charcoal (C)
Station 11	Jar of Colored Beads
Station 12	Ethanol(C_2H_6)
Station 13	Salt Water
Station 14	Sand/Charcoal
Station 15	Air

Classification of Matter Activity #1

Objective: To visualize & distinguish between elements, compounds, homogeneous mixtures, and heterogeneous mixtures.

Procedure: You will visit each station and record the following (make a chart):

• Observations of what the substance looks like
• Draw a picture representing the model
• Record if it has a symbol or formula, and if so, what it is

Analysis:

1. Make 4 categories: elements, compounds, homogeneous mixtures, heterogeneous mixtures. Categorize the substances from the stations.
2. How did you determine what category a substance would go in? Explain your reasoning.
3. Explain the difference between compounds and mixtures.
4. Explain the difference between homogeneous and heterogeneous mixtures.
5. Looking at the pictures below, categorize them as an element, compound, homogeneous or heterogeneous mixture. (Any molecular level pictures can be used for this question.)
Ex.:

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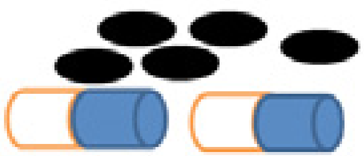
Explain: After students have gathered their data from the stations, they will develop their chart for Analysis question #1. Before they move on to the other questions, I have students share how they categorized the different substances, and as a class, we develop a chart that correctly displays the information.

Elaborate: The second activity was developed by my colleague and fellow chemistry teacher, Laura Littrell. The second activity was a modified version of the Classification of Matter activity from POGIL: Activities for High School Chemistry book sold by Flinn Scientific, Inc., which is a fantastic resource.

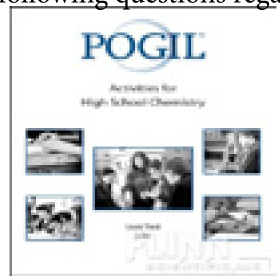


(http://www.flinnsci.com/store/Scripts/prodView.asp?idproduct=22349)

Below is the first page of the activity, and the questions follow.

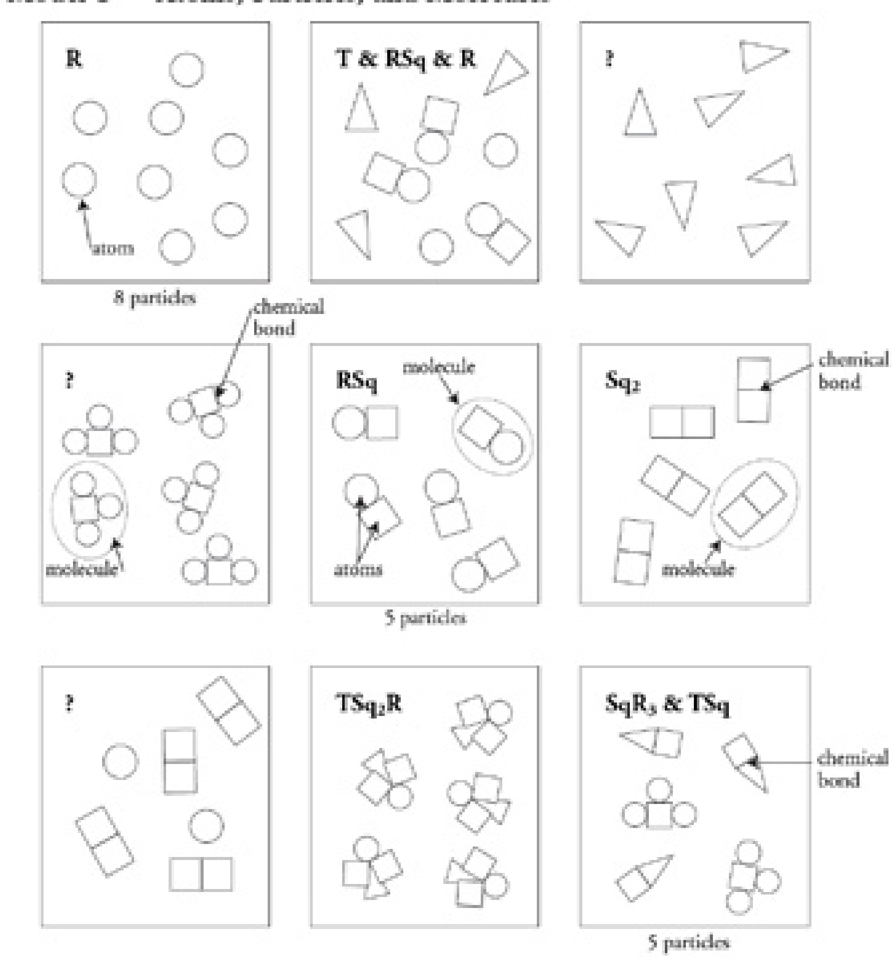
Classification of Matter Activity #2

1. Answer the following questions regarding the pictures in



Model 1

- How are particles defined in Model 1?
- In the pictures, what is the difference between atoms and molecules?



Classification of Matter

How do atoms combine to make different types of matter?

Why?

Look at the things in this room. They are all matter. That matter may be pure or it may be a mixture. Can you tell by looking at it? What if you looked at it under a microscope? Then could you tell? Something that looks pure may not really be pure. It depends on what type of particles an object or substance is made of. In this activity we will explore how the smallest chemical units of matter determine whether something is classified as an element, a compound, or a mixture.

Model 1 — Atoms, Particles, and Molecules

Classification of Matter 1

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- When two or more atoms are touching in the picture, what holds them together?

2. Compare the codes listed at the top of each drawing in Model 1 with the shapes in that box.

- What do the letters R, Sq, and T in the codes represent?
- What do the small numbers (subscripts) in the codes represent?
- When atoms are touching, how is that communicated in the code?
- What is the common characteristic of the samples in which an ampersand (&) is used?
- In Model 1 there are three drawings that are labeled with a question mark. Write codes to properly label these drawings.

3. Now, cut apart Model 1 to separate the nine drawings. As a team, sort the drawings into two groups.
4. Matter can be classified into two groups, pure substances and mixtures. Students are given index cards to label "pure substance" and "mixture".
5. Place the pure substance card and the mixture card with the correct group.
6. Based on your determination, write a definition for pure substances.
7. Write a definition for mixtures.
8. Next, take the pictures you put in the pure substance group and separate them into two new groups. Students are given index cards to label "elements" and "compounds".
9. Place the element and compound cards with their correct group.
10. Write a definition for elements.
11. Write a definition for compounds.
12. How are the codes for elements different from those for compounds?
13. Use what you have just learned about chemical formulas to identify each of the following as an element, a compound or a mixture:
    a. Br2
    b. NaHCO3
    c. C6H12O6 (sugar) & H2O
    d. Cu & Zn
    e. CO2
    f. Al
14. What do you think is different between an atom and an element?
15. What do you think is different between a molecule and a compound?
16. Think of the four categories you split your pictures into, make a concept map to organize these four categories on a blank piece of paper. Under each category, complete the following:

- Write a definition of each category.
- Draw your own picture to represent the difference in structure of each category.
- Write the substances listed in number thirteen below the correct category.
- Write a new example of an element, compound, or mixture.

17. The categories in your concept map can be classified even further. They can be homogeneous which means the same throughout or heterogeneous which means different throughout. Which category, mixtures or pure substances would **always** be considered homogeneous? Explain.

Evaluate:

After a final discussion of the various student definitions and the technical textbook definitions, students are given a Classification of Matter worksheet which contains various examples and pictures of elements, compounds and mixtures to classify.

KCAS Connections

Making connections to grade level KCAS math standards

ELEM / MS

Robin Hill
KDE Math Consultant

NGSS Appendix L assists teachers with making connections between NGSS and Common Core State Standards for mathematics (CCSSM is the same as Kentucky's – KCASM). It is important that educators take great care when interpreting and implementing the NGSS. The math that students are being asked to perform should not outpace or be misaligned to the grade-by-grade standards in the CCSSM (KCASM).[1] See Table 1 for a list of key math topics relevant to science with grade level and alignment notes. This article takes a look at the Physical Science 1: Matter and Its Interactions for grades 5 and 6 with some appropriately aligned math standards.

For instance, at grade 5 in the KCASM students are developing an understanding of volume but are limited to rectangular solids. With this limitation in mind, teachers should still provide students with opportunities to recognize volume as an attribute of three-dimensional space[2] and provide students with opportunities to work with volume to develop an understanding of very small along with very large quantities.[3] Students can be given the volume with appropriate labeling or asked to read measurement increments

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from a beaker or cylinder. The math standards that are listed may correlate to activities and tasks that are planned for 5-PS1-1.

NGSS (KCAS Science) 5-PS1-1 Develop a model to describe that matter is made of particles too small to be seen.

KCAS.Math 5.NBT.A.1 Recognize that in a multi-digit number, a digit in one place represents 10 times as much as it represents in the place to its right and 1/10 of what it represents in the place to its left.

Alignment note: Students at grade 5 will work to develop an understanding of the place value system in base ten.[4]

KCAS.Math 5.NBT.A.2 Explain patterns in the number of zeros of the product when multiplying a number by powers of 10, and explain patterns in the placement of the decimal point when a decimal is multiplied or divided by a power of 10. Use whole-number exponents to denote powers of 10.

Alignment note: Students at grade 5 are not required to use or understand scientific notation. Writing numbers using scientific notation and performing mathematical operations with numbers written in scientific notation are expectations of students in grade 8.[5]

KCAS.Math 5.NF.B.7 Apply and extend previous understandings of division to divide unit fractions by whole numbers and whole numbers by unit fractions.

Alignment note: In grade 5 students are not required to divide a fraction by a fraction. They are limited to dividing unit fractions by whole numbers and dividing whole numbers by unit fractions.[6]

Solve real world problems involving division of unit fractions by non-zero whole numbers and division of whole numbers by unit fractions, e.g., by using visual fraction models and equations to represent the problem.

1. Example from NGSS Appendix L: Split a salt grain with weight 1 mg into 10 equal parts; find the weight of each part. (Answer in mg.) Then Divide each of the parts into 10 equal parts, find the weight of one of the new parts. (Answer in mg.) How many parts are there in the end?

In this example students are dividing a whole number by a whole number and then a fraction by a whole number. This problem could be extended to ask students to show the sum of the weights of the parts equals the whole salt grain. Students can also compare the weight of a part of the salt grain to the weight of the whole salt grain. Considering the standard below (5.MD.A.1) students could also be asked to convert the weights of the parts to grams.

KCAS.Math 5.MD.A.1 Convert among different-sized standard measurement units within a given measurement system (e.g., convert 5 cm to 0.05 m), and use these conversions in solving multi-step, real world problems.

Alignment note: Students at grade 5 are limited to converting units within a given measurement system. At grade 6 students begin working with ratios and rate reasoning using tables, graphs, unit rates and percents including converting measurement units. At grade 7 students compute in like or different units.[7]

2. Example from NGSS Appendix L: When 100 g of sugar is dissolved in 0.5 kg of water, what is the total weight of the system? Answer in grams, then answer in kilograms. After the water evaporates, see how much the sugar residue weighs.

By using grams and kilograms students are converting within the same measurement system, recognizing different units of measure and demonstrating how to convert to common units of measure. This real world example assists students with explaining patterns and operations with base ten numerals.

3. Example from NGSS Appendix L: Suppose a salt grain with weight 1 mg is split into 10 equal parts, and each of those parts is split into 10 equal parts, and so on, until there are 10 (8) parts. What is the weight of one of those tiny parts? Write the number of those tiny parts as a whole number without using exponents.

This example stays within the limitations of grade 5 by having students write the number without using scientific notation. Writing numbers using scientific notation and performing mathematical operations with numbers written in scientific notation are expectations of students in grade 8. At grade 5 students are limited to whole number exponents to denote powers of 10.

At grade 6, students begin writing, interpreting and explaining rational numbers in context; however, they do not formally begin using mathematical operations with rational numbers until grade 7. Students at grade 6 also begin to work with ratio concepts and use ratio reasoning to solve problems. Students at grade 7 extend this understanding to analyzing proportional relationships and using this understanding to write and solve multi-step ratio and percent problems. Teachers should provide students with opportunities to work with fractions including fractions divided by fractions, to use rational numbers (signed numbers), to write and solve equations, to compute percents, to use order of magnitude thinking and to summarize numerical data sets.(8) The math standards that are listed may correlate to activities and tasks that are planned for 6-PS1-1.

NGSS MS-(KCAS Science)-6-PS1-1 Develop models to describe the atomic composition of simple molecules and extended structures.

KCAS.Math 6.RP.A.3 Use ratio and rate reasoning to solve real-world and mathematical problems, e.g., by reasoning about tables of equivalent ratios, tape diagrams, double number line diagrams, or equations.

a. Make tables of equivalent ratios relating quantities with whole-number measurements, find missing values in the tables, and plot the pairs of values on the coordinate plane. Use tables to compare ratios.

b. Solve unit rate problems including those involving unit pricing and constant speed. *For example, if it took 7 hours to mow 4 lawns, then at that rate, how*

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many lawns could be mowed in 35 hours? At what rate were lawns being mowed?

c. Find a percent of a quantity as a rate per 100 (e.g., 30% of a quantity means 30/100 times the quantity); solve problems involving finding the whole, given a part and the percent.

d. Use ratio reasoning to convert measurement units; manipulate and transform units appropriately when multiplying or dividing quantities.

1. Example from NGSS Appendix L: A pile of salt has mass 100 mg. How much chlorine is in it? Answer in milligrams. What would the answer be for a 500 mg pile of salt?

2. Example from NGSS Appendix L: Based on a model of a water molecule, recognize that any sample of water has a 2:1 ratio of hydrogen atoms to oxygen atoms.

By exploring equivalent ratios and rates through relative size of quantities, mixtures and compounds, students are provided opportunities to connect their understanding of multiplication and division with ratios and rates as they learn about properties of matter. Students at grade 6 are not expected to analyze proportional relationships or solve multi-step problems involving ratios or percents.[9]

KCAS.Math 6.NS.C.7 Understand ordering and absolute value of rational numbers. Interpret statements of inequality as statements about the relative position of two numbers on a number line diagram. *For example, interpret $-3 > -7$ as a statement that -3 is located to the right of -7 on a number line oriented from left to right.*

a. Write, interpret, and explain statements of order for rational numbers in real-world contexts. *For example, write -3 ⁰ C is warmer than -7 ⁰ C.*

b. Understand the absolute value of a rational number as its distance from 0 on the number line; interpret absolute value as magnitude for a positive or negative quantity in a real-world situation.

3. Example from NGSS Appendix L: Use positive and negative quantities to represent temperature changes in a chemical reaction (signs of energy released or absorbed).

In grade 6 students are not required to perform mathematical operations on rational numbers (signed numbers).[10] So, if students are exposed to problems involving change in temperature that involves negative numbers, it should occur after they have had time to explore and develop an understanding of ordering numbers using their positions on a number line diagram and interpreting statements of inequality between two numbers using their positions. Special attention should be given to finding the change in temperature rather than setting up simple equations and finding difference through subtraction.

KCAS.Math 6.SP.B.4 Display numerical data in plots on a number line, including dot plots, histograms, and box plots.

KCAS.Math 6.SP.B.5 Summarize numerical data sets in relation to their context, such as by:

a. Reporting the number of observations.

b. Describing the nature of the attribute under investigation, including how it was measured and its units of measurement.

c. Giving quantitative measures of center (median and/or mean) and variability (interquartile range and/or mean absolute deviation), as well as describing any overall pattern and any striking deviations from the overall pattern with reference to the context in which the data were gathered.

4. Example from NGSS Appendix L: Compile all the boiling point measurements from the class into a line plot and discuss the distribution in terms of clustering and outliers. Why weren't all the measured values equal? How close is the average value to the nominal/textbook value? Show the average value and the nominal value on the line plot.

KCASM Glossary: Line plot or dot plot is a method of visually displaying a distribution of data values where each data value is shown as a dot or mark above a number line.

(1) NGSS Appendix L http://www.nextgenscience.org/sites/ngss/files/Appendix-L_CCSS%20Math%20Connections%2006_03_13.pdf

(2) http://www.corestandards.org/Math/Content/5/introduction

(3) http://nextgenscience.org/ 5.PS.1 Matter and Its Interactions

(4) http://www.corestandards.org/Math Grade 5 Number and Operations in Base Ten

(5) http://www.corestandards.org/Math Grade 8 Expressions and Equations

(6) http://www.corestandards.org/Math Grade 5 Number and Operations – Fractions

(7) http://www.corestandards.org/Math Grade 7 Ratios and Proportional Relationships

(8) http://nextgenscience.org/ MS.PS.1 Matter and Its Interactions

(9) http://www.corestandards.org/Math Grade 6 Ratios and Proportional Relationships

(10) http://www.corestandards.org/Math Grade 6 The Number System

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Table 1: Key Math Topics Relevant to Science & Grade with Alignment Notes

Number and Operations	**Grade with alignment notes**
Multiplication and division of whole numbers	Multiply and divide numbers within 100 – Grade 3; multiply a whole number of up to four-digits by a one-digit whole number and multiply two two-digit whole numbers – Grade 4; divide up to four-digit whole number by one-digit whole number – Grade 4
Concept of a fraction a/b (visual representations are essential.)	Grade 3
Fraction arithmetic (using mathematical operations: add, subtract, multiply and divide)	Add and subtract fractions with like denominators – Grade 4; Add and subtract fractions with unlike denominators – Grade 5; Multiply a fraction by a whole number – Grade 4; Multiply fractions – Grade 5;Divide whole number by unit fraction and unit fraction by a whole number – Grade 5; Divide fraction by a fraction – Grade 6
Decimals	Add, subtract, multiply and divide decimals to hundredths –Grade 5
The coordinate plane	quadrant I – Grade 5; all four quadrants – Grade 6
Ratios, rates (e.g., speed), proportional relationships	Ratio and rates – Grade 6; proportional relationships – Grade 7
Percent problems	Simple percent problems – Grade 6; Multi-step percent problems – Grade 7
Rational number system / signed numbers—concepts	Grade 6
Rational number system / signed numbers—arithmetic (using mathematical operations: add, subtract, multiply and divide)	Grade 7
Exponents	Use whole number exponents to denote powers of 10 – Grade; evaluate using whole number exponents – Grade 6; apply properties of integer exponents (+ and – whole numbers) and scientific notation – Grade 8
Measurement	**Grade with alignment notes**
Standard length units (inch, centimeter, etc.)	Standard length units – Grade 2; perimeter of polygons – Grade 3; circumference of circle – Grade 7
Area	Area of rectangles by counting unit squares – Grade 3; area of rectangles and triangles – Grade 6; area of circle – Grade 7
Convert from a larger unit to a smaller in the same system	Grade 4
Convert units within a given measurement system	Grade 5
Volume	Volume of right rectangular prism – Grade 5; volume of spheres and cylinders – Grade 8
Convert units across measurement systems (e.g., inches to cm)	Grade 6
Statistics and Probability	**Grade with alignment notes**
Statistical distributions (including center, variation, clumping, outliers, mean, median, range, quartiles and mean absolute deviation),	Grade 6
Statistical association or trends (including two-way tables, bivariate measurement data, scatter plots, trend line, line of best fit, correlation).	Grade 8
Probability, including chance, likely outcomes, probability models	Grade 7

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Building steam

ALL

Robert Duncan
Kde Arts and Humanities Consultant

What do Science, Technology, Engineering and Math (STEM) have to do with the arts? Educators from pre-school through graduate levels are excited about the concept of STEAM: Science, Technology, Engineering *ARTS* and Math.

The soft skills of creativity, critical thinking and application of learning in real life situations occur readily in the arts classrooms.

From STEM to STEAM: how the Arts are claiming their rightful place among core subjects is featured in the January issue of the PTA publication *Our Children*.

The current issue also features articles on the importance of the arts in the Common Core and an interview with singer Tony Bennett and his views of the importance of maintain strong arts programs in schools.

KCAS Literacy Standards in Science: "Whew! that was a close read!"

ALL

Carol Mullins
KDE Regional Instructional Specialist

A priority of the Kentucky Core Academic Standards (KCAS) for English/Language Arts and Literacy in History/Social Studies, **Science** and Technical Subjects is that students must closely read texts of increasing complexity to acquire knowledge. The literacy standards strongly focus on students gathering evidence, knowledge, and insight from what they read. This requires that a majority of questions and tasks that students are asked and respond to (both orally and in writing) be based directly on a text they are required to read.

It is very important to note that science relies on evidence. A true scientist knows that scientific ideas must be tested — preferably with many different lines of evidence, not just textual evidence. This characteristic is at the heart of all science. Scientists, literacy specialists and science teachers also understand that students need specialized reading skills in order to fully comprehend complex scientific text. It must be emphasized that the literacy standards are not intended to replace KCAS science standards – only to supplement them and provide students with the much needed skills for reading scientific information.

The International Reading Association publication "Engaging the Adolescent Learner: Text Complexity and Close Reading," (Fisher and Frey, January 2012) offers this short reply to the question, "*How do texts differ across the disciplines?",* when referring to science.

> "**Science:** Technical vocabulary and dense sentences that require the reader to draw on multiple concepts simultaneously. For example: "Eukaryotic cells also have a variety of subcellular structures called organelles, well-defined, intracellular bodies that perform specific functions for the cell. (*Modern Biology*, 2006, p. 75, cited in Fang & Schleppegrell, 2011, pp. 588–589)."

Not only do the common core standards in ELA and Literacy require students to "read closely to determine what the text says explicitly and to make logical inferences from it," they must also cite pertinent evidence from the text when responding orally or when writing an answer to questions about the text. Students can no longer rely solely on prior knowledge or personal experience and the NGSS indicate this through their designated connections (cite textual evidence) to the Literacy in Science Standards.

Let's begin an example of the NGSS and KCAS Literacy Standards connections with a short explanation of terminology and the skills teachers and students need:

What is a Close Read? *(Sometimes called a Close Analytical Read)*

Close reading is looking at and reading technical text and breaking it down into logical components to help better understand the text. It involves a re-reading of the text using *text-dependent questions.*

Additional steps are explained to enhance a Close Reading at:
http://www.reading.org/Libraries/members-only/Fisher_and_Frey_-_Text_Complexity_-_January_2012.pdf

What are Text-Dependent Questions?

- questions that can only be answered correctly by close reading of the text and demand careful attention to the text.
- require an understanding that extends beyond recalling facts.
- often require students to infer.
- do not depend on information from outside sources.
- allow students to gather evidence and build knowledge.
- provide access to increasing levels of complex text.
- call for careful and thoughtful teacher preparation.
- require time for students to process.
- worth asking.

Teachers must move instruction away from generic questions such as, "What is the main idea and three supporting details?" to questions that require students to analyze what they are reading.

Students need to revisit the text for evidence to support their conclusions in a thoughtful, careful and precise way.

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Additional information for developing effective text-dependent questions:
http://www.missionliteracy.com/page78/page72/assets/FisherFrey%20Text%20Dependent%20Questions%20April%202011.pdf
http://www.achievethecore.org/page/396/understanding-text-dependent-questions

6th Grade
Sample lesson utilizing an article and text-dependent questions
MS. Structure and Properties of Matter

Students who demonstrate understanding can:

- 06-PS1-4. Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed. [Clarification Statement: Emphasis is on qualitative molecular-level models of solids, liquids, and gases to show that adding or removing thermal energy increases or decreases kinetic energy of the particles until a change of state occurs. Examples of models could include drawings and diagrams. Examples of particles could include molecules or inert atoms. Examples of pure substances could include water, carbon dioxide, and helium.]

NGSS Common Core State Standards Connections: ELA/Literacy

- RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions (06-PS1-3)
- RST.6-8.7 Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). (06-PS1-1),(06-PS1-4)

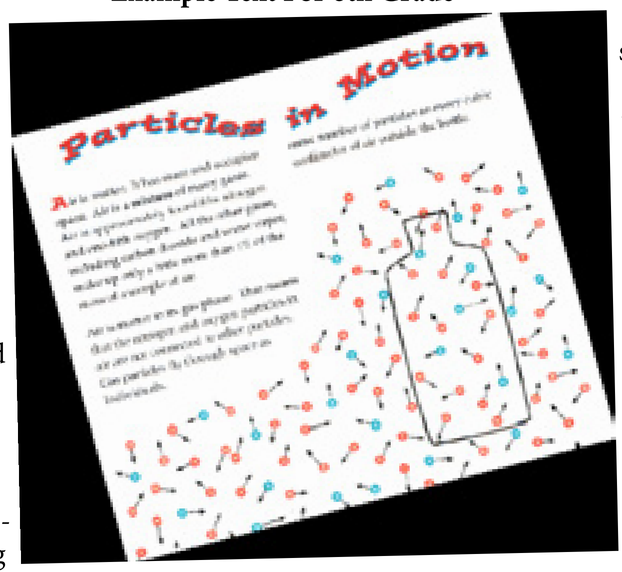
Particles in Motion (Chemical Reactions)**
(http://bpsscience.weebly.com/uploads/2/2/1/3/2213712/8_particles_in_motion_chemical_interactionsgrade_8.pdf

**Please note that this article is recommended for 8th grade, but based on the Text Complexity requirements and the NGSS it is more appropriate for Kentucky 6th graders.

Example 6th Grade Text-Dependent Questions For "Particles In Motion"

- According to the text, what combination of elements makes up air? Use evidence from the text to create a pie chart showing the percentages of elements found in the air.
- As stated in the text, "the density of the air in the bottle is exactly the same as the density of the air outside the bottle". Use the illustration (found in the article) to help infer what density means based on this statement.
- Based on the context of the sentence "Kinetic energy like all forms of energy can do work", what is the meaning of the word "work" as it appears in the article?
- What explanation does the author provide to explain why a balloon inflates when a bottle-and-balloon system is placed in hot water?

Example Text For 6th Grade



"80-90% of (CCSS) reading standards require text-dependent analysis yet over 30% of questions in major textbooks do not." (Susan Pimentel, lead writer of the CCSS: ELA/Literacy, 2010). Virtually every standard can be activated during the course of every close analytic reading through the use of effective text-dependent questions.

Because students do not automatically reread text as required in a close analytical reading, teachers need to create and use text-dependent questions that redirect students to the text to provide evidence and support for their answers (Fisher, Frey, & Lapp, 2012).

An important strategy is that teachers prepare effective text-dependent questions in advance of the reading, considering questioning techniques such as question-answer relationships, questioning the author, and Bloom's taxonomy to ensure deep thinking is achieved.

Remember, the goal is to develop the students' prowess at drawing knowledge from the text itself.

Science for All

Science Resources for Teachers of EL Students

ALL

Gary Martin
Division of Learning Services

Kentucky's membership in World-Class Instructional Design and Assessment (WIDA) provides more than an English language proficiency assessment for Kentucky EL

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student population. It makes many resources and professional development available to teachers who serve EL students daily.

A large array of webinars are available to Kentucky teachers through the WIDA download library (http://www.wida.us/downloadLibrary.aspx) District EL Coordinators can assist teachers in accessing the Kentucky webinars on ELD Standards in Action: Differentiation and Access Score Interpretation. The WIDA Download Library archives webinars from other states on a variety of EL topics that can also be viewed.

A very important resource that is available in the WIDA Download Library is the English Language Development (ELD) Standards which should be implemented for all EL students in Kentucky. WIDA has worked to connect the WIDA standards framework to state content standards. The standards are drawn from the Common Core State Standards (CCSS) and the Next Generation Science Standards (NGSS).

The 2012 Amplification of The English Language Development Standards contain strands of Model Performance Indicators (MPIs) for each grade level. The strands of MPIs are examples that illustrate differentiated language expectations related to content-area instruction within a language domain.

The Kentucky webinar on Differentiation will assist teachers on how to use this with their lessons and EL students.

The Kentucky Department of Education through WIDA will provide a web-based training Introduction to the ELD Standards on April 28.

The time of the webinar has not been established by the WIDA facilitator.

Additional information will be emailed to all districts EL Coordinators and registration will be set up through CIITS once the time has been finalized.

Be In The Know

ALL

Kathy Mansfield
Library Media/Textbooks Consultant

The KY Virtual Library (KYVL) provides valuable text supports for the implementation of Kentucky Core Academic Standards which emphasize the use of digital resources for inquiry research and require extensive research-based informational writing from students for all content areas. More than 30 databases give students and teachers access to scholarly and popular journal articles, local/state/national newspapers, online encyclopedias, news/radio program transcripts, and primary sources for K-12 students in the Commonwealth.

KYVL offers databases for every grade level, with content screened for age-appropriateness – unlike content that may be found through Google, Wikipedia, or other Internet sources. Both KYVL and KYVL database vendors provide regular, free professional development opportunities for educators.

Did you know? Kentucky's K-12 students (from 112 participating districts) conducted more than 4 million searches in KYVL databases during the 2012-13 school year.

Did you know? K-12 students in Kentucky districts that subscribe to KYVL have access to articles from such kid-friendly periodicals as *Time for Kids*, *Ranger Rick*, *Sports Illustrated for Kids*, *National Geographic Kids*, *Faces*, *Cobblestone*, and *Highlights for Children*. Hundreds of other magazines and newspapers are accessible by the click of a mouse, too.

The current core collection of KYVL resources includes the following databases geared specifically toward K-12 students:

- **Amazing Animals of the World (Grolier)** Database *Continued from Page 13* available through Grolier Online which contains reference and media materials on 1200 animals for grades 2 and above
- **Encyclopedia Americana (Grolier)** Encyclopedia available through Grolier Online with in-depth information for older students and adults
- **Funk and Wagnalls New Encyclopedia (EBSCO)** Features over 25,000 informative segments of the encyclopedia
- **Grolier Multimedia Encyclopedia (Grolier)** Encyclopedia available through Grolier Online with rich media for middle school and higher
- **MAS Ultra - School Edition (EBSCO)** This comprehensive database, designed specifically for high school libraries, contains full text for nearly 500 popular, high school magazines including *America's Civil War*, *American Heritage*, *American History*, *American Visions*, *Archaeology*, *Astronomy*, *Bioscience*, *Careers + Colleges*, *Civil War Times Illustrated*, *CQ Weekly*, *Discover*, *Economist*, *History Today*, *Nation*, *National Review*, *New Republic*, *New Scientist*, *Popular Science*, *Science News*, *Scientific American*, *Smithsonian*, *World War II*, etc. All full text articles

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are assigned a reading level indicator (Lexile). Full text is also available for 88,000 biographies and 60,000 primary source documents. Additionally, MAS Ultra (School Edition) contains more than 540 pamphlets, nearly 150 reference books (including the Columbia Encyclopedia, the CIA World Fact Book and World Almanac + Book of Facts), an Image Collection of 91,000 photos, maps + flags, color PDF and expanded full text back files (back to 1975) for key magazines.

- **Middle Search Plus (EBSCO)** Middle Search Plus, designed specifically for middle school libraries, contains full text for more than 140 popular, middle school magazines. All full text articles are assigned a reading level indicator (Lexile). Full text is also available for biographies, historical essays and student pamphlets. Additionally, Middle Search Plus contains primary source documents including Essential Documents in American History, reference books including the Funk + Wagnall's New Encyclopedia and American Heritage Dictionary, 4th Edition from Houghton Mifflin, the Encyclopedia of Animals and an Image Collection. This database is designed to assist middle and junior high school students in learning how to research current events. This database can be accessed via Searchasaurus, EBSCO's search experience for elementary-to-middle school-age users.
- **New Book of Knowledge (Grolier)** Encyclopedia available through Grolier Online with reference and current events for elementary school and higher
- **NoveList (EBSCO)** Novelist is an electronic readers' advisory resource that assists fiction readers in finding new authors and titles. In includes 90,000 full text reviews, over 36,000 subject headings and a complete spectrum of searching options, including searching by title, by author or simply by describing pertinent plot details.
- **Primary Search (EBSCO)** Designed for elementary schools and children's reading rooms, Primary Search Online covers a wide range of general interest topics. This database can be accessed via Searchasaurus, which is EBSCO's unique search experience designed specifically for elementary-to-middle school-age users. Additionally, Primary Search includes the Encyclopedia of Animals, and features the Funk + Wagnall's New Encyclopedia, which provides students with easy-to-read encyclopedic entries written specifically for kids. This database also provides the American Heritage Children's Dictionary, 3rd Edition from Houghton Mifflin, and an Image Collection of 91,000 photos, maps and flags. All full text articles are assigned a reading level indicator (Lexile).
- **Teacher Reference Center** This index of over 260 titles from the most popular teacher and administrator trade journals, periodicals, and books is now also offered free via the EBSCO host platform. This database provides coverage on key education topics such as Assessment, Continuing Education, Current Pedagogical Research, Curriculum Development, Instructional Media, Language Arts, Literacy Standards, Science & Mathematics, and more for K-12 Teachers & Librarians.

In addition to providing access to these valuable licensed resources, KVYL subscriptions also enable individual schools to purchase additional resources at a discount through KYVL's Master Agreements with vendors such as Encyclopedia Britannica, HW Wilson, and Gale.

For more information about KYVL, contact Enid Wohlstein, KYVL Director (enid.wohlstein@ky.gov) or Kathy Mansfield, KDE Library Media/Textbooks Consultant (kathy.mansfield@education.ky.gov).

Resources

CIITS update

ALL

Joe McCowan

Are you aware of the science resources currently in CIITS? Take some time to access the standards that include aligned materials and also be sure to check out PD 360 for professional learning footage that can help you connect instructional planning support. All school districts are able to access these materials along with the ability to create, share and collaborate electronically. Also, Christine Duke and I are in the process of setting up a Next Generation Science Standards collaborative group in PD 360 for any Kentucky educator to join and share ideas. This will be an interactive work space to help us share ideas related to the NGSS. Christine will send out related communication about where to access this site and how to join soon. Please also continue to use the digital suggestion box on your CIITS homepage to offer ideas or areas you think we need to improve. We will be adding more materials and we need you to let us know what you think about the materials as well as help us create and share high quality materials aligned to the standards.

Science Connection continues on Page 14

Professional Learning Opportunities

Science/engineering happenings

Engineering Exposition (E-Expo) March 1, 2014

The J.B. Speed School of Engineering at the University of Louisville is hosting Engineering Exposition (E-Expo) on March 1, 2014. E-Expo is a day-long event held every year to showcase the exciting opportunities at U of L as well as engage younger students into the joys of engineering. Throughout the day, there will be multiple competitions, hands-on activities, lab tours, and a special keynote speaker . The main goal with E-Expo is to unite students, industry, and the community by inspiring innovation and ingenuity in the minds of future generations.

This event is open to all ages, with competitions for elementary, middle, and high school students.

This is an exciting opportunity as it will help reinforce real world applications to what teachers are teaching in the classrooms.

School groups or individuals are invited to attend as well as compete in the competitions.

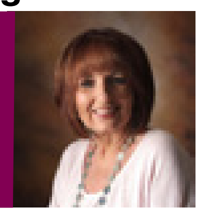
More information on E-Expo, such as the schedule, registration, competitions, etc., can be found at the website, engineering-expo.com, but please fill free to call with any questions or concerns.

2013-14 professional development opportunities

Presented by PIMSER at the University of Kentucky College of Education

Outstanding Formative Assessment

... a close focus 1-day workshop



Presented by author and assessment expert Shirley Clarke, University of London
March 11, 2014

This training will introduce new examples of the elements of formative assessment (learning culture, planning, learning objectives, success criteria, talk and questioning, and feedback). Learn practical strategies for incorporating the elements of formative assessment in the classroom, using clips of Seamus Gibbons, an exceptional inner London teacher, to illustrate what the strategies look like in practice. The training also will highlight successful staff-development strategies.
$125 for the 1-day session

Complete details at www.rsvpbook.com/formassessoneday.

Professional Developers Institute

Using Elementary and Middle School Mathematics: Teaching Developmentally

PROFESSIONAL DEVELOPMENT EDITION

Presented by co-author Jennifer Bay-Williams
March 6-7, 2014

Supporting implementation of the CCSS-Mathematics Content and Mathematical Practices. Learn how to use the book *Using Elementary and Middle School Mathematics – Professional Development Edition* directly from one of the authors. Bay-Williams will focus on specific aspects of the book that connect to the CCSS Content and Mathematical Practices, engage you in professional development activities that are in the book and consider ways the book can help in your work with teachers, principals, parents and students!

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$300 includes purchase of book, or $175 if you already have a copy.

Complete details at www.rsvpbook.com/pdinstitute.

The Kentucky Writing Project and the Kentucky Department of Education present

Science Literacy through Science Journalism

Eastern Kentucky University (Richmond): March 1, 2014 (8:30 a.m.-3 p.m.) in the New Science Building

What: This day-long workshop will support you in engaging students in meeting the new Common Core Standards for research through the SciJourn process (www.scijourn.org). Based on a 4-year NSF-funded research project demonstrating that teaching science journalism using reliable data sources and science-specific writing standards improves students' understanding of and literate engagement in science. Participants are invited to join the KWP SciJourn Network to receive follow-up support and share their students' experiences with like-minded teachers.

Cost: $125 per person (Early Bird price, $100 by Feb. 15). Registration includes lunch and text: Front Page Science: Engaging Teens in Science Literacy (NSTA Press). 6 hours of professional development credit provided.

Who: Middle and High School science teachers and language arts teachers interested in authentic writing experiences for their students.

Facilitators: KWP SciJourn Director Marsha Buerger; KWP SciJourn Leadership Team Members Lisa Antoniou & Billie Jo Thornsberry

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The Nineteenth Annual Regional BRIDGE BUILDING CHAMPIONSHIPS March 1, 2014

at WKU Center for Research & Development Commons Area

You are invited to be a part of the nineteenth annual Regional Bridge Building Championships. Through the sponsorship of WKU SKyTeach, WKU Dept. of Architectural & Manufacturing Sciences, and the WKU Dept. of Engineering we are proud to once again provide one of the best regional contests in the nation.

The contest will be held on Saturday, March 1, 2014 at WKU Center for Research & Development Commons Area, 2413 Nashville Rd, Bowling Green, KY. This is the old Bowling Green Mall.

As the official regional affiliation for the International Bridge Building Contest, our top two finishers in the high school division will qualify for the international competition in Chicago. Bridges must be within specifications of the Bridge Building Contest rules. This year's rules may be found on-line at http://brimsbridgebuildingcontest.wikispaces.com/

Tip Sheets have been prepared to clarify the rules and give bridge design and construction tips are also available at the same location online.

Please note that each bridge must be designed and built by individual students – no 'group' or 'team'bridges are allowed.

A schedule for February 28 & March 1 and bridge kit ordering information is included on the website.Feel free to contact Christal Wade, Event Coordinator, at brims.bridge@gmail.com with questions about the competition.

Collaboration and Connections:

The Science Connections Newsletter offers a forum for science professionals across Kentucky to collaborate and share classroom experiences. You are encouraged to share instructional strategies, resources and lessons that you have learned with colleagues across the state. Note that your entries should relate to one, or all, of the topics for the next month as noted below.
Below are the upcoming SCN focus dimensions:

Coming up:	Science and Engineering Practice	Disciplinary Core	Crosscutting Concept
March	Analyze and Interpret Data	LS2: Interdependent Relationships in Ecosystems	System and System Models
April	Constructing Explanations and Designing Solutions	ESS2: Plate Tectonic and Large Scale Systems	Energy and Matter

E-mail your contributions to christine.duke@education.ky.gov.

All submissions are needed by the 25th of the month.